National Aeronautics and Space Administration

NASA/GSFC Orbital Debris Research Priorities

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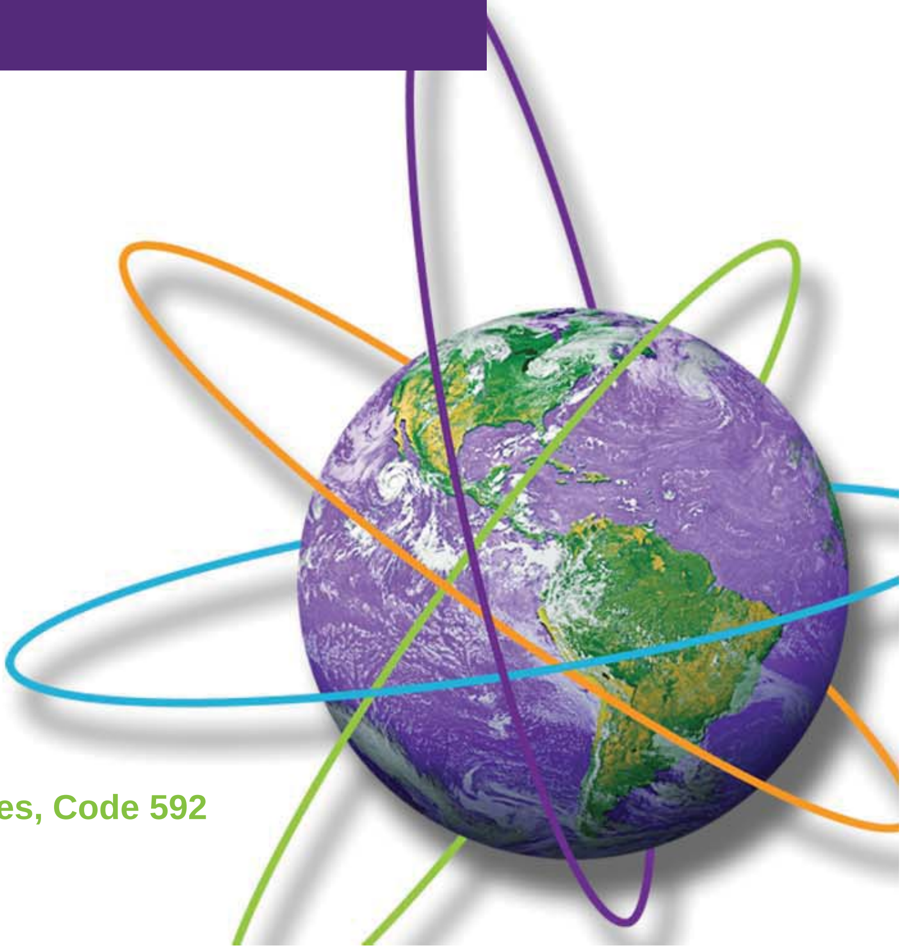

Research Opportunities

- Drag Enhancement Device Collision Probability
- Postmission Attitude Effects on Drag
- Safe and Reliable Power System Passivation Options
- Safe and Effective Bipropellant Passivation Options
- Pressurant Venting Options for EOM Passivation
- Small Object Penetration Failure Criteria

Drag Enhancement Device Collision Probability

- Drag enhancement is clearly effective for reducing the orbital lifetime of retired vehicles
- Can be used to meet the ‘25 year rule’
  - Could enable high altitude CubeSats to meet guidelines

- What is the effect on the overall collision probability?
  - Shorter orbital time, but larger area
  - Random collision with large objects
  - Potential to break up 1 – 10 cm objects, creating more debris
- Trends over altitude range, inclination, device size, etc
- Software-driven experiments (relatively low cost)
- Documentation could help to justify adoption of these devices

Postmission Attitude Effects on Drag

- Orbital lifetime estimates are strongly driven by the drag area, which is in turn driven by attitude
  - Important design assessment for ‘25 year rule’ compliance
- When Attitude Control Subsystem is passivated, natural forces dominate
  - Gravity gradient vs. drag
  - Moments of Inertia vs. ballistic coefficient
  - Eventually the spacecraft tumbles, but when?

- Driving factors need to be studied specific to EOM
- Assessment tool development for estimating transition to tumble and resulting orbital lifetime

Safe and Reliable Power System Passivation Options

- Power systems should be passivated for reasons beyond preventing battery explosion
- Designers are reluctant to design in that capability
  - Creates a potential single point of failure
  - May allow accidental premature end of mission
  - Legacy designs without that capability

- Options can be identified and published
  - Disabling solar array input power to the spacecraft
  - Disabling battery charging
  - Demonstrate the need
- Study the challenges of intermittent charging at EOM
  - Spacecraft left power-negative except when arrays are illuminated
  - Spacecraft is effectively power-cycled as it rotates

Safe and Effective Bipropellant Passivation Options

- Incompletely passivated bipropellant propulsion systems have the potential to explode after the mission
  - Residual amounts of fuel and oxidizer remain, under pressure
  - Any leak that allows them to contact can cause explosion
  - Vehicles can be left above GEO for centuries

- Options need to be developed to exhaust propellants safely after the mission
- Complications
  - Varying pressure conditions; potential for backflow
  - Thruster valves usually actuate both sides together
  - Launch vehicles use pre-loaded commands
  - Isolated pressurant prevents ‘flushing’ with the inert gas

Pressurant Venting Options for EOM Passivation

- Residual pressurant leaves tanks under stress
  - More susceptible to rupture on MMOD impact
  - Very long term tank stability is unknown (GEO = centuries)
  - Diaphragm propellant tanks or isolated pressurant tanks
- Designs for venting are not complex, but designers are reluctant to incorporate them

- Demonstrate the need for passivation
- Demonstrate the safety of the designs
- Study and report the costs in terms of mass and reliability

Small Object Penetration Failure Criteria

- Little is known about the failure criteria for MMOD hypervelocity penetration of some component types
  - How much damage can be withstood before the device fails?
  - Is any box wall penetration fatal, or is damage more localized?
  - Secondary debris damage, possible plasma generation

Wire Bundles	RF Waveguides
Avionics Boxes	Power Boxes

- Permanent failures are more of a concern than short term disturbances
- Testing is needed to characterize these failure criteria
- Most testing requires expensive hypervelocity impact testing on representative components, so funding is needed

Conclusions

- There are a variety of research opportunities available to support the prevention of new debris

- Most of these opportunities are cost-effective and immediately applicable to new designs

- Knowledge from the proposed research can help to increase compliance with orbital debris mitigation guidelines

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